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LAKE GRANT, BROWN COUNTY, OHIO

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH
LABORATORY

JUNE 1975

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

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Report
on
Lake Grant
Brown County
Ohio
EPA Region V
Working Paper No. 401

With the cooperation of the
Ohio Environmental Protection Agency
and the
Ohio National Guard
June, 1975

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Youger, Ohio Environmental Protection Agency, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

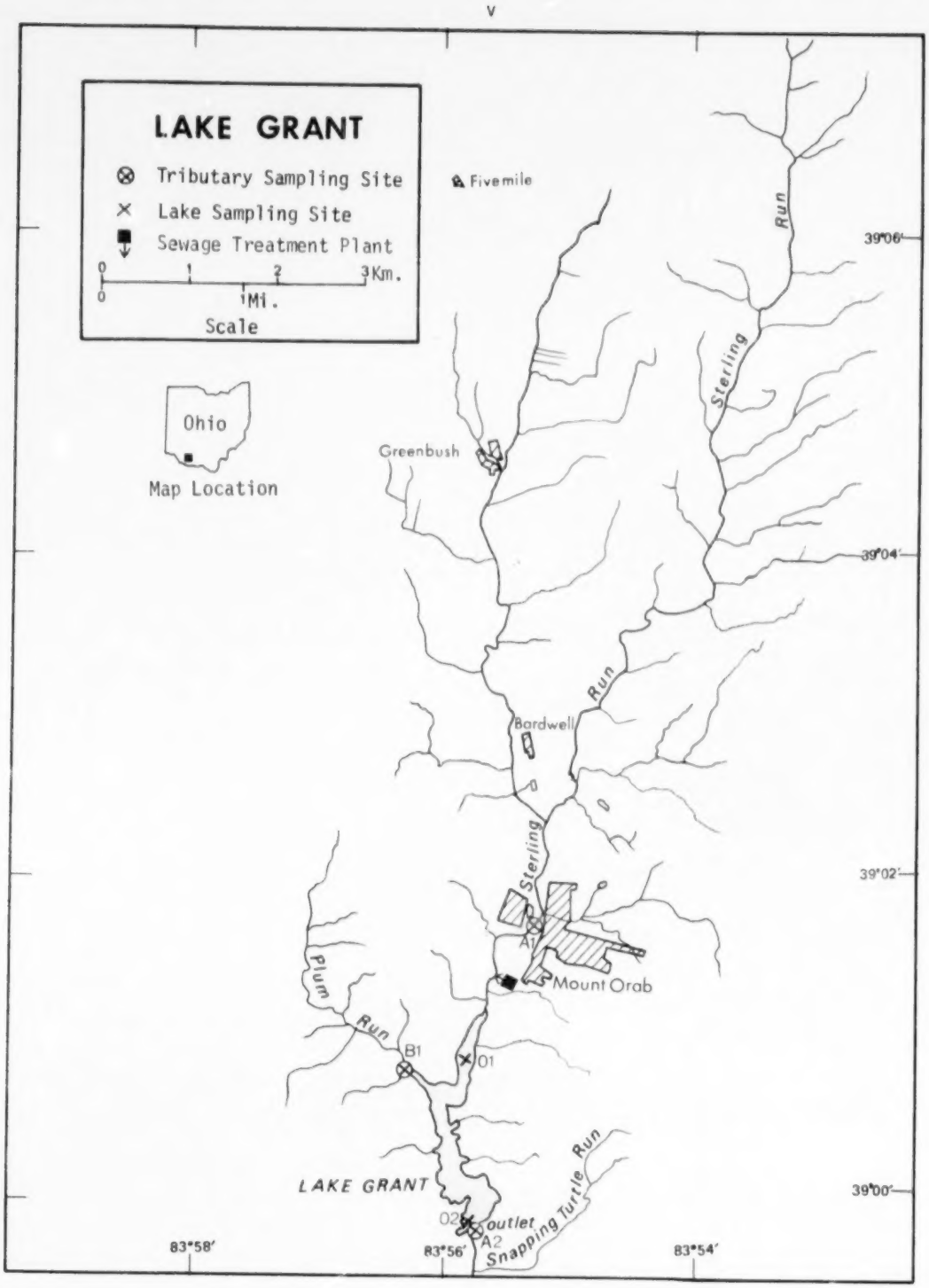
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


LAKE GRANT
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Plant
0 1 2 3 Km.
0 1 Mi.
Scale
Ohio
Map Location
Fivemile
Greenbush
Bardwell
Mount Orab
Sterling Run
Run
Sterling
Plum Run
Snapping Turtle Run
LAKE GRANT
outlet
A1
A2
B1
01
02
39°06'
39°04'
39°02'
39°00'
83°58'
83°56'
83°54'

LAKE GRANT

STORET NO. 3912

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Grant is eutrophic. Among the 20 Ohio lakes studied, Lake Grant ranked thirteenth in overall trophic quality when compared using a combination of six parameters*. Ten lakes had less median total phosphorus, 12 had less median dissolved phosphorus, eight had less median inorganic nitrogen, 13 had less mean chlorophyll a, and 16 had greater mean Secchi disc transparency.

Survey limnologists noted that Lake Grant was turbid both sampling times; and a considerable growth of rooted aquatic vegetation in the shallows along the shorelines at both sampling stations was observed.

B. Rate-Limiting Nutrient:

Lake Grant was not sampled in the spring, and no algal assay sample was collected. The lake data indicate phosphorus limitation in August and October.

C. Nutrient Controllability:

1. Point sources--It is estimated that the Mount Orab wastewater treatment plant accounted for nearly 23% of the total phosphorus load to Lake Grant during the sampling year. The

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* See Appendix B.

calculated phosphorus loading of 8.51 $g/m^2/yr$ is over 8 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). However, the mean hydraulic retention time of Lake Grant is a rather short 24 days, and Vollenweider's model probably does not apply.

While even complete removal of phosphorus at the Mount Orab wastewater treatment plant would still leave a loading in excess of a eutrophic loading, in view of the questionable applicability of Vollenweider's model, it is likely that a high degree of phosphorus removal would result in a reduction in the incidence and severity of nuisance algal blooms (note that the phosphorus input of the Mount Orab facility would constitute a significantly greater proportion of the total load during the summer and fall months when algal blooms are most troublesome and when non-point phosphorus contributions are minimal because of low stream flows). Rooted aquatic vegetation probably would not be affected by the phosphorus reduction, however, because of the alternate source of nutrients in the bottom sediments of the lake.

2. Non-point sources--It is estimated that non-point sources, excluding precipitation, contributed about 77% of the total phosphorus loading to Lake Grant during the sampling year.

The phosphorus export rates of Sterling Run and Plum Run were somewhat high during the Survey sampling year (see page 10).

However, the rates of the two tributaries were essentially identical; and since Plum Run was not impacted by point sources, it is concluded the rates resulted from land-use practices in the Lake Grant drainage area.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 0.76 kilometers^2.
2. Mean depth: 1.9 meters.
3. Maximum depth: 8.1 meters.
4. Volume: 1.468 x 10^6 m^3.
5. Mean hydraulic retention time: 24 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Sterling Run	53.1	0.6
Plum Run	5.2	<0.1
Minor tributaries & immediate drainage -	9.0	0.1
Totals	67.3	0.7

2. Outlet -

Sterling Run	68.1**	0.7

C. Precipitation***:

1. Year of sampling: 127.5 centimeters.
2. Mean annual: 111.0 centimeters.

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† Table of metric conversions--Appendix B.
†† Youger, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Grant was sampled two times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and usually from two or more depths at each station (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 5.5 meters at station 1 and 6.4 meters at station 2.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR GRANT LAKE
STORET CODE 3912

PARAMETER	1ST SAMPLING (8/ 1/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (10/ 9/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (**/**/**) 0 SITES RANGE	MEAN	MEDIAN
TEMP (C)	25.2 - 25.8	25.5	25.5	20.4 - 21.2	20.6	20.4	******	**********	
DISS OXY (MG/L)	3.9 - 4.6	4.2	4.2	2.8 - 9.2	4.9	2.8	******	**********	
CNDCTVY (MCROMO)	204. - 244.	223.	222.	173. - 186.	177.	175.	******	**********	
PH (STAND UNITS)	7.3 - 7.7	7.5	7.4	7.1 - 8.6	7.7	7.5	******	**********	
TOT ALK (MG/L)	55. - 73.	62.	61.	52. - 56.	54.	54.	******	**********	
TOT P (MG/L)	0.113 - 0.257	0.184	0.183	0.159 - 0.227	0.199	0.204	******	**********	
ORTHO P (MG/L)	0.019 - 0.045	0.030	0.029	0.020 - 0.033	0.025	0.024	******	**********	
NO2+NO3 (MG/L)	0.420 - 0.810	0.620	0.625	0.040 - 0.160	0.125	0.150	******	**********	
AMMONIA (MG/L)	0.260 - 0.490	0.377	0.380	0.090 - 0.450	0.272	0.275	******	**********	
KJEL N (MG/L)	0.900 - 1.700	1.350	1.400	1.400 - 1.700	1.575	1.600	******	**********	
INORG N (MG/L)	0.910 - 1.150	0.997	0.965	0.130 - 0.610	0.397	0.425	******	**********	
TOTAL N (MG/L)	1.710 - 2.120	1.970	2.025	1.560 - 1.850	1.700	1.695	******	**********	
CHLRPYL A (UG/L)	45.2 - 46.7	45.9	45.9	46.7 - 100.6	73.6	73.6	******	**********	
SECCHI (METERS)	0.4 - 0.5	0.4	0.4	0.3 - 0.3	0.3	0.3	******	**********	

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
08/01/73	1. *Melosira* sp.	5,415
	2. *Stephanodiscus* sp.	4,459
	3. *Nitzschia* sp.	1,384
	4. *Trachelomonas* sp.	590
	5. *Cryptomonas* sp.	570
	Other genera	2,692
	Total	15,110
10/09/73	1. *Oscillatoria* sp.	22,091
	2. *Melosira* sp.	16,300
	3. Centric diatoms	14,584
	4. Pennate diatoms	10,938
	5. Flagellates	9,008
	Other genera	33,674
	Total	106,595

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
08/01/73	01	46.7
	02	45.2
10/09/73	01	100.6
	02	46.7

C. Limiting Nutrient Study:

An algal assay sample was not collected since Lake Grant was not sampled in the spring. However, the lake data indicate phosphorus limitation in August and October; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 33/1 and 16/1, respectively, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of March and April when two samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the the nutrient loads, in kg/km^2/year, at station B-1 and multiplying by the ZZ area in km^2.

The Village of Mount Orab did not participate in the sampling program, and nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Mount Orab	1,306	ext. aer.	494.3**	Sterling Run

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Sterling Run	3,890	60.2
Plum Run	395	6.1
b. Minor tributaries & immediate drainage (non-point load) -	685	10.6
c. Known municipal STP's -		
Mount Orab	1,480	22.9
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation*** -	15	0.2
Total	6,465	100.0

2. Outputs -

Lake outlet - Sterling Run 5,480

3. Net annual P accumulation - 985 kg.

* Anonymous, 1971.
** Estimated at 0.3785 m^3/capita/day.
*** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Sterling Run	29,610	68.5
Plum Run	3,055	7.1
b. Minor tributaries & immediate drainage (non-point load) -	5,290	12.2
c. Known municipal STP's -		
Mount Orab	4,440	10.3
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	820	1.9
Total	43,215	100.0

2. Outputs -

Lake outlet - Sterling Run 52,300

3. Net annual N loss - 9,085 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Sterling Run	73	558
Plum Run	76	588

* See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	8.51	1.30	56.9	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Grant:	
"Dangerous" (eutrophic loading)	1.04
"Permissible" (oligotrophic loading)	0.52

* There was an apparent loss of nitrogen during the sampling year. This may have been due to nitrogen fixation in the lake, solubilization of previously sedimented nitrogen, recharge with nitrogen-rich ground water, unknown and unsampled point sources discharging directly to the lake, or underestimation of the nitrogen loads from the Mount Orab STP. Whatever the cause, a similar nitrogen loss has occurred at Shagawa Lake, Minnesota, which has been intensively studied by EPA's National Eutrophication and Lake Restoration Branch (Malueg et al., 1975).

V. LITERATURE REVIEWED

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Malueg, Kenneth W., D. Phillips Larsen, Donald W. Schults, and Howard T. Mercier; 1975. A six-year water, phosphorus, and nitrogen budget for Shagawa Lake, Minnesota. Jour. Environ. Qual., vol. 4, no. 2, pp. 236-242.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Youger, John, 1975. Personal communication (lake morphometry). OH Env. Prot. Agency, Columbus.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3901	BEACH CITY RESERVOIR	0.122	1.490	489.000	10.867	11.600	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	9.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	67.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.098	2.980	470.125	9.887	13.900	0.036
3907	DELAWARE RESERVOIR	0.086	2.340	484.111	10.856	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.640	462.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	76.855	14.200	0.012
3917	LORAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.058	0.150	465.333	36.267	11.600	0.006
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	462.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.900	465.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.575	465.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.208	3.070	479.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.040	0.280	466.111	37.711	15.000	0.007

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	290
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LORAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	429
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	16 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3928	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLEASANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	392
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	292
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	3908	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR OHIO 03/09/76

LAKE CODE 3912 GRANT LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 68.1

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3912A1	53.1	0.99	1.19	1.30	1.05	0.62	0.34	0.22	0.18	0.12	0.10	0.27	0.57	0.58
3912A2	68.1	1.27	1.53	1.70	1.36	0.79	0.42	0.28	0.23	0.15	0.12	0.34	0.74	0.74
3912B1	5.2	0.09	0.12	0.14	0.11	0.06	0.03	0.02	0.02	0.01	0.01	0.02	0.05	0.06
3912ZZ	9.8	0.18	0.23	0.26	0.21	0.12	0.06	0.04	0.03	0.02	0.02	0.05	0.10	0.11

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 68.1
SUM OF SUB-DRAINAGE AREAS = 68.2
TOTAL FLOW IN = 8.96
TOTAL FLOW OUT = 8.94

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3912A1	5	73	0.59	5	0.34				
	6	73	0.74	9	0.22				
	7	73	1.25	8	0.11				
	8	73	0.22	18	0.08				
	9	73	0.02	15	0.02				
	10	73	0.40	13	0.06				
	11	73	1.73	18	0.22				
	12	73	1.27	15	0.65				
	1	74	1.90	19	7.42				
	2	74	0.57	22	1.47				
	3	74	1.42	8	0.93	16	5.72		
	4	74	1.16	3	1.98	20	0.16		
3912A2	5	73	0.74	5	0.42				
	6	73	0.93	9	0.28				
	7	73	1.59	8	0.14				
	8	73	0.27	18	0.10				
	9	73	0.02	15	0.02				
	10	73	0.48	13	0.07				
	11	73	2.18	18	0.28				
	12	73	1.64	15	0.82				
	1	74	2.41	19	9.40				
	2	74	0.74	22	1.93				
	3	74	1.84	8	1.22	16	7.45		
	4	74	1.53	3	2.63	20	0.21		

TRIBUTARY FLOW INFORMATION FOR OHIO 03/09/76

LAKE CODE 3912 GRANT LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
391281	5	73	0.06	5	0.03				
	6	73	0.07	9	0.02				
	7	73	0.12	8	0.01				
	8	73	0.02	18	0.01				
	9	73	0.00	15	0.0				
	10	73	0.03	13	0.01				
	11	73	0.15	18	0.02				
	12	73	0.12	15	0.06				
	1	74	0.18	19	0.71				
	2	74	0.06	22	0.16				
	3	74	0.15	8	0.10	16	0.59		
	4	74	0.12	3	0.21	20	0.02		
3912ZZ	5	73	0.11						
	6	73	0.14						
	7	73	0.22						
	8	73	0.04						
	9	73	0.00						
	10	73	0.06						
	11	73	0.28						
	12	73	0.24						
	1	74	0.34						
	2	74	0.11						
	3	74	0.28						
	4	74	0.23						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/01/02

391201
39 00 52.0 083 55 48.0
GRANT LAKE
39 OHIO

11EPALES 2111202
3 0022 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/08/01	14 00	0000	25.8		14	240	7.40	66	0.420	1.600	0.490	0.045
	14 00	0003	25.6	3.9		244	7.50	73	0.490	1.700	0.420	0.038
73/10/09	15 00	0000	21.2	9.2	12	186	8.60	54	0.090	1.600	0.040	0.020

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/08/01	14 00	0000	0.257	46.7
	14 00	0003	0.240	
73/10/09	15 00	0000	0.209	100.6

STORET RETRIEVAL DATE 76/01/02

391202
38 59 49.0 083 55 52.0
GRANT LAKE
39 OHIO

11EPALES
3

2111202
0025 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/08/01	14 20	0000	25.5		18	204	7.70	55	0.260	1.200	0.760	0.019
	14 20	0007	25.2	4.6		204	7.30	55	0.340	0.900	0.810	0.020
73/10/09	15 10	0000	20.5		12	175	7.80	52	0.200	1.700	0.150	0.026
	15 10	0005	20.4	2.8		173	7.30	54	0.350	1.600	0.150	0.033
	15 10	0011	20.4	2.8		174	7.10	56	0.450	1.400	0.160	0.022

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/08/01	14 20	0000	0.127	45.2
	14 20	0007	0.113	
73/10/09	15 10	0000	0.200	46.7
	15 10	0005	0.159	
	15 10	0011	0.227	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/03

3912A1
39 01 42.0 083 56 17.0
STERLING RUN
39119 7.5 MT ORAB
I/GRANT LAKE
HWY 74 BRDG IN MOUNT ORAB
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	08 45		0.336	1.320	0.048	0.052	0.180
73/06/09	10 30		0.450	1.200	0.078	0.044	0.145
73/07/08	08 45		0.560	2.100	0.100	0.069	0.185
73/08/18	08 45		0.260	0.735	0.056	0.063	0.125
73/09/15	08 35		0.200	0.720	0.063	0.050	0.180
73/10/13	09 10		0.075	1.450	0.087	0.066	0.200
73/11/18	11 30		0.470	1.000	0.036	0.112	0.280
73/12/15	10 10		0.570	0.800	0.104	0.076	0.195
74/01/19	08 55		0.840	1.100	0.048	0.055	0.240
74/02/22	08 30		0.520	4.800	0.120	0.050	0.220
74/03/08	13 00		0.276	1.500	0.055	0.060	0.350
74/03/09	08 50		0.352	1.700	0.050	0.060	0.465
74/04/03	17 45		0.252	1.300	0.080	0.055	0.190
74/04/20	09 00		0.232	0.900	0.015	0.010	0.025

STORET RETRIEVAL DATE 75/02/03

3912A2
38 59 47.0 083 55 44.0
STERLING RUN
39 7.5 HAMMERSVILLE
0/GRANT LAKE
ST HWY 774 BRDG S END OF LAKE
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09 07		0.180	1.500	0.140	0.060	0.170
73/06/09	10 55		0.010K	2.400	0.032	0.037	0.265
73/07/08	09 00		0.680	4.400	1.500	0.054	0.172
73/08/18	09 00		0.240	1.100	0.030	0.044	0.130
73/09/15	08 45		0.115	1.000	0.065	0.021	0.120
73/10/13	09 20		0.011	1.600	0.054	0.015	0.135
73/11/18	11 45		0.216	1.400	0.068	0.092	0.340
73/12/15	10 20		0.288	0.900	0.160	0.088	0.230
74/01/19	09 05		0.610	0.800	0.090	0.070	0.165
74/02/22	08 40		0.490	4.800	0.240	0.050	0.230
74/03/08	13 05		0.561	1.300	0.185	0.055	0.310
74/03/16	09 05		0.368	1.500	0.085	0.050	0.315
74/04/03	18 00		0.108	1.600	0.075	0.050	0.345
74/04/20	09 10		0.320	2.000	0.110	0.030	0.340

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/02/03

391281
39 00 45.0 083 55 17.0
PLUM CREEK
39 7.5 MT ORAB
T/GRANT LAKE
PLEASANT HILL RD BRDG
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09	22	0.126	1.760	0.110	0.035	0.192
73/06/09	10	35	0.010K	1.500	0.020	0.015	0.095
73/08/18	09	15	0.100	1.600	0.168	0.054	0.220
73/09/15	09	00	0.011	1.470	0.026	0.014	0.210
73/10/13	09	30	0.010K	1.500	0.027	0.021	
73/11/18	12	00	0.370	1.100	0.044	0.080	0.240
73/12/15	10	12	0.384	1.000	0.084	0.074	0.160
74/01/19	09	15	0.700	1.100	0.060	0.045	0.195
74/02/22	08	50	0.440	1.100	0.085	0.045	0.165
74/03/08	13	10	0.192	1.200	0.085	0.040	0.260
74/03/16	09	15	0.352	1.200	0.035	0.060	0.300
74/04/03	18	10	0.184	2.050	0.110	0.055	0.365
74/04/20	09	20	0.360	1.400	0.060	0.055	0.180

K VALUE KNOWN TO BE
LESS THAN INDICATED